ENVIRONMENTAL POTENTIAL OF CITY AREA: INTEGRAL ASSESSMENT OF THE FACTORS FORMING ENVIRONMENTAL SITUATION IN THE CITY OF MINSK

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Abstract
Sustainable decision-making in the city requires the informational base integrated the different factors forming the city environment. The one of the most effective tool to interpret the diverse information is integrative assessment of the area. The main goal of the research was making an integrative evaluation of the environmental potential of the territory of the city of Minsk. Environmental potential is understood as a capacity of the area to shape the type of environmental conditions depending on specific combination of physical environment and land use pattern. The methodology of integrative assessment is based on the evaluation of potential influence of two blocks of factors (natural and antropogenical) on the main components of the environment – air, water, geology/soils. As the result the area of the city has been analyzed from the viewpoint of potential sustainability of the spatial complexes to the current and planned land-use. 26 individual spatial complexes - urban landscapes (UL) - have been divided into 6 groups with different value of environmental potential.

Introduction
The researches on the city environment take on special significance since the urban areas undergone the most intensive human impact. The recent trends of sustainable development attract a special attention to the problems of environmentally sound urban management based on multidisciplinary studies on interaction between natural potential of the territory and its use. Integrated landscape and city-planning investigations became the one of the instruments enable adapting the survey data to the needs of wide circle of municipal stakeholders. Practical orientation of the research results attaches the great importance to possibility to apply the findings for the purposes of management and optimization of city planning. (1)
Minsk is the capital of the Republic of Belarus, its cultural, business, and industrial center. Like many of European cities, Minsk features the radial-ring planning pattern. The process of developing new areas was carried out evenly enough from the city core toward the periphery with gradual incorporation of the outlying areas. At the same time the landscape pattern has a stair-like structure and orients in the line with the Svisloch river valley stretch. The peculiarities of natural basis of the area and the character of city land-use cause the environmental conditions and life quality in the city in many respects.

Methods
Spatial analysis of land-use / land-cover structure of city area
Geographical approach to the analysis of the natural and anthropogenic factors forming the environmental situation within the city of Minsk based on the methodology of landscape-ecological analysis predetermines the main goals of the research: 1) to analyze the modern spatial pattern of Minsk, which is resulted from interactions between physical environment and area's land use; 2) to make integrative evaluation of the environmental potential of the area. We understand *environmental potential* as a carrying capacity of the area to shape the type of environmental conditions depending on specific combination of physical environment and land use pattern. The practical orientation of the research encourages us to interpret the evaluation results for the practical needs of different actors involved in the city planning process. The major way of presentation the scientific data might be integrated environmental assessment based on the results of investigation. Visualization of the result could be considered as the additional interpreting tool that has significant importance for the dialog of the municipal stakeholders, especially for those of them who have no their professional interests directly linked with environmental science (i.e. architects, economists, etc.).

The analysis of spatial structure consists of 3 principal blocks: 1) study of spatial structure of physical land-cover; 2) study of city land-use; 3) integrated analysis of land-use / land –cover structure of the area. The subjects of the research for block 1 and 2 are the natural and antropogenical spatial complexes regarded as independent substructures. The complicated land-use / land –cover structure of the territory, its specifics and spatial organization has been considered to be a subject of the research of block 3. There are 2 main stage of investigation in every block: 1) determination of elementary units of spatial structure and making of the basic maps; 2) generalization of the information, clarification of the peculiarities of spatial structure of the whole city.

Landscape map serves as the base for the analysis of natural basis of the territory. Landscape mapping is found on classical approaches of Belarusian landscape school (2) and have been carried out on the base of large-scale topographic map of the city, the map of quaternary deposits, geomorphologic map, personal investigations of the author. Genesis of the territory served as the main criterion for delimitation of *landscapes* while the character of meso-relief and litogenous substratum defined the borders of *sites*. On the base of landscape mapping and available data classification of natural sites of the territory of Minsk have been fulfilled (3). Being comparatively small areas, the sites have been considered as the structural-functional elementary spatial units of natural basis. To make an optimal base for analysis of natural complex of the whole city area the procedure of division into *land-cover districts* has been fulfilled on the base of landscape map and natural sites classification. The land-cover districts *LCD* are the areas with specific combination of the sites determined the peculiarities of natural complex functioning and its possible reaction on antropogenic impact. The specifics of combination of the sites as well as its spatial characteristics (dimensions, configurations, others) have been taken into account when dividing the districts. The territory of the city have been divided into 10 landscape districts.

Analysis of man-made environment of the city has been fulfilled on the base of the map of building morphotypes. As the morphotypes of building and open spaces (the term has been proposed in the work devoted to city-planning zoning of Moscow (4) we consider the areas with comparatively uniform building characteristics. Mapping has been carried out on the base of factual data, maps and field investigations. To make a map of building morphotypes for the territory of Minsk the varied approaches to the different types of functional use of the area have been applied. To characterize the residential and public areas the number of storeys and building density have been chosen as determinative factors. The character of internal (in-block) green spaces and type of functional land-use serves as complimentary factors. For the industrial areas the main factors of identification were the character and level of environmental impact. Unbuilt areas occupied by plants have been divided according to the peculiarities of vegetation.

The same way as in case of natural basis, the spatial complexes of morphotypes have been considered to be elementary units of spatial structure. On the base of the map fulfilled, factual data and field observations, city *land-use districts* have been divided. Land-use districts *LUD* are the areas with the specific combination of morphotypes that the combination determines peculiarities of city land-use complex functioning, the character of its interaction with the natural basis and possible environmental impact. Beside 'objective' indexes, the factors like visual and psychological perception of the area as a single whole have been taken into account. There are 15 land-use districts have been divided on the territory of Minsk. The districts have been named according to traditional names of city regions, main streets.

Partition of natural-antropogenical territorial complexes - *urban landscapes* - was the resulting stage of landscape and city-planning analysis. Urban landscapes *UL* have been divided by overlapping the contours of landscape and city-planning districts, splitting, overlay compilation. To define the borders of urban landscapes the boundaries of city-planning districts have been considered as a dominating factor because the city-planning framework characterized by certain limits and reflects a replacement of the one urban landscape by another more correctly.

Therefore the urban landscapes divided are the individual areas with comparatively same landscape and city-planning characteristics possessed the typical feature of certain landscape and city planning districts. The titles of UL include the information about geographical location in the borders of the city, genesis, relief character (natural block) and dominating morphotypes (land-use block). For the matter of generalization and systematization of the data the classification of urban landscape of Minsk that has been fulfilled. The area of the city of Minsk has been divided on 26 urban landscapes.

Evaluation of the environmental potential of urban landscapes

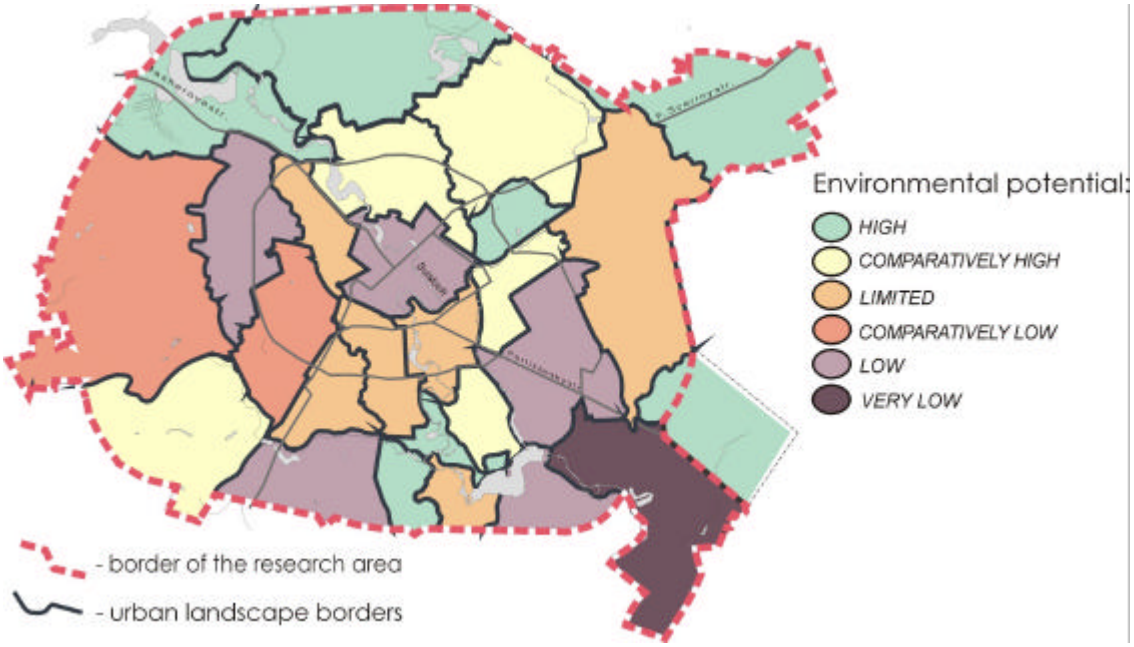
The final step of the environmental analysis of spatial structures is environmental assessment of the city. There are several methods of integral evaluation which contain different basic principles, methodology and factual base. When analyzing the different approaches to environmental

assessment we may note that they are mainly about to describe environmental conditions of the moment. Obviously, this kind of analysis is very helpful for the determination of local environmental problems. However the weak point is that this approach does not necessary reflect the roots of the problems. At the same time policy- and decision-makers operate with the factors and forces, which potentially *shape* environmental situation. They regulate rather forces, than the consequences of their actions.

The main goal of integrated evaluation of Minsk's urban landscapes is to assess potential inputs of different components of land-cover and land-use factors in the process of shaping the environmental situation in the city. The potential influence of 5 factor groups such as: A) natural (physical land-cover) – 1) geographical location within the city, 2) natural landscape pattern, 3) recent city hydrological network and vegetation; B) antropogenic (land-use) – 4) characteristics of the buildings of residential and public estates, 5) characteristics of industrial estates and intensity of environmental impact of industrial areas have been analyzed regarding to the 3 main components of environment, such as: 1) air, 2) surface and ground waters, 3) geological environment and soil.

The procedure of numerical score assessment have been fulfilled for each of 26 urban landscapes. The procedure of integral assessment consists of 3 levels. The primary "level of single factors assessment" deals with the factors of physical land-cover and land use and their influence on the environmental situation. Significant difference in the character of the influence do not allow following up and correct assessment of the impact of every factor on every of 3 component of environment. The next "level of complex assessment" generalize the information within the factor groups and allows to conclude about the influence of every of 5 group of factors on every of 3 selected components of environment. Every evaluation step "1 factor / 1 component of environment" is resulted by the division of the urban landscapes into 4 groups – with the *high*, *moderate*, *low* and *insignificant* influence of the assessing factor group. The final "level of integral assessment" results the assessment of environmental potential of urban landscapes. The final score for the urban landscapes have been calculated as the difference between total score of natural potential (regarded as a "positive" impact of natural sustainability) and land-use conditions (regarded as a "negative" destabilizing impact of antropogenic factors). As the result, 26 urban landscapes have been aggregated into 6 groups with different value of *environmental potential* understood as a capacity of the area to shape the type of environmental conditions depending on specific combination of physical environment and land use pattern. (Figure 1)

Figure 1: Environmental potential of urban landscapes of the city of Minsk



Visualizing of the results

The orientation of the research towards implementation requires needs to reflect results in a universal form that clearly reflect the main blocks of assessment and may be used by different city-planning actors. So far the city system is very flexible structure that constantly changes spatially and temporally the visual form, which gives the possibility to reflect the dynamic changes in land cover / land use conditions. For this purpose the diagrams of the evaluation of environmental potential of urban landscapes have been worked out. The diagram visual model has been named *DARTS* – Diagram of Assessment of Regional Territorial Systems.

The main segments of the diagram are the factor rings and influence sectors. 5 rings represent the main group of factors. Intensity and character of impact of every group of factors on the selected component of environment are indicated by the color (light / dark), direction (clockwise / anticlockwise), and the length of the arrows within factor rings & influence sectors. 3 influence sectors correspond to the 3 of the main environmental blocks: air, water, geology & soils. Every sector is divided into 3 sub-sectors that reflect the intensity of impacts: 4 evaluation groups. Intensity of positive influences of the physical environment is marked in clockwise direction in light color on dark background. Intensity of negative impact is marked in anticlockwise direction in dark color in light background. Thus, correlation between the light and dark colors within the DARTS indicates the factors forming the specific environmental situation within the territory of urban landscape and their input in the resulting level of environmental potential.

Results & Discussion

As the result of analysis of spatial structure of natural land-cover structure the territory of Minsk 4 natural landscapes have been delimited: hilly-moraine-eroded landscape with deciduous-fir, pine forests on sod-podzol soils; moraine-zander landscape with deciduous-fir, pine forests on sod-podzol soils; fluvial-glacial with pine forests on sod-podzol soils; the landscape of whole river valleys with pine forests on sod-podzol soils and meadows on turfy-swamp soils. 33 species of natural sites have been marked off in the borders of the landscapes. The sites of watersheds on the complex of moraine and kame deposits with middle- and small-hilly, hilly-undulating relief dominate on the territory of Minsk and sort form the western, south-western, northern and, partly, the eastern regions of the city. Almost the same area corresponds to the sites of watersheds on the complex of fluvial-glacial and moraine-zander deposits with hilly-undulating, undulating, flat relief which dominate in the central, southern, south-eastern parts of the city. In spite of comparatively small area the sites of river valleys, hollows of drain and depressions on the complex of alluvial, diluvia and swampy deposits serves as important elements in forming of spatial structure of natural basis.

The map of morphotypes allows reflecting the specific features of land-use pattern of the city. As the most typical residential and public estates the areas covered with middle- and high-storey buildings constructed in 60^{th} - 80^{th} could be considered. The appearance and parameters of residential and public areas are defined by the different factors: city-planning 'age' of building area, geographical location in the borders of the city, peculiarities of functional use, character of vicinities, etc. Prevalence of high- and middle-density building with middle level of green areas is typical for a large city. As compared with the residential and public areas, the segments of industrial and transport-storehouse use are much more uniform. Their parameters are highly depended upon defined standards and less flexible. The middle-intensive industrial and transport-storehouse territories are spread on almost all the area of the city. The largest factories form a limited number of comparatively compact high-intensive industrial zones. The most typical green areas of the city are the territories of parks with trees and shrubbery plants. The segments of spontaneous and natural-like plants correspond to riverside zones, hollows of drain. Extensive open spaces are typical for the city periphery. As a rule, these territories have no defined type of use – outlying reserved areas, waste grounds, agricultural lands.

The spatial structure and configuration of 26 urban landscapes in Minsk are determined by two basic tendencies: gradual extension of the city-planning units in the direction from the center of the city to its outskirts and orientation of the Svisloch river valley. Significant part of the city – the areas of the most prolonged and intensive development – was formed and is used without taking the local peculiarities of natural landscapes into account. The components of natural environment on these areas are greatly transformed. As compared with "old" parts, the later developed regions situated on the periphery partly takes the specifics of the natural landscape structure into consideration. Sometimes it is achieved by rational planning, in the other cases, extensive development of the outlying areas allows leaving several spaces vacant. The highest degree of the correspondence between the city-

planning structure and natural basis is obtained in the western part of the city. The main elements of the natural landscape structure are taken into consideration when planning and developing the river valleys, hollows of drain, depressions.

The analysis of spatial distribution of environmental potential allows making conclusion about how the correlation between the land-cover and land-use structure within the urban landscape might effect environmental situation. The highest level of environmental potential characterizes the territories with considerable carrying capacity of physical land-covering in the north-eastern and northern part of Minsk. Unlike the northern areas, the high level of environmental potential of small group of UL located in the south part of Minsk resides in comparatively low level of natural sustainability accompanied with very limited intensity of land-use. The lowest level of environmental potential characterizes the southern and south-eastern part of Minsk. Geographical location wising the city together with the high intensity of industrial use cause the transfer and accumulation of pollutants in the south and south-east. At the same time the strategy of city development declared in the Strategic Development Plan of Minsk (adopted in 2002) considers the southern areas as the main direction for city spread. In the case if the certain policies of the Strategic Development Plan will not be revised the coming decades could face the significant part of city dwellers with the environmental problems caused by the failures of planning policy.

Conclusions

Comparative analysis of land-cover and land-use pattern of the city area allows delineating of natural-antropogenical spatial entities - urban landscapes (UL) - that could be considered as the most regular elements of spatial structures combined the specific features of physical land-cover and land-use characteristics and could be used as the base for the spatial analysis and environmental management on the municipal level.
Evaluation of environmental potential of urban landscapes (EPU) fulfilled for the 26 urban landscapes of the city of Minsk enables reflecting the main reasons of environmental problem caused by influence of natural landscape cover and recent city land-use. Visualization of the results of evaluation allows presenting the roots of environmental problems to different actors of city management and policy.
According to the result of EPU assessment the highest level of sustainability characterize the urban landscapes of northern, partly – eastern and western parts of Minsk. These areas could be considered for the further intensification of land-use as well as the most perspective direction of city grows. The limited number of urban landscapes with high environmental potential caused by low level of city land-use development located within the river valleys need to be preserved from intensive transformation because they serves as the important elements of ecological framework of the city territory. The southern and south-eastern areas offers in the new Strategic Development Plan of Minsk as the main direction of city grows are characterized by the lowest level of environmental potential. Natural carrying capacity of these territories coupled with current and planned land-use would not support permissible level of environmental quality for the newly developed city areas.

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